EXHIBIT C

UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF OKLAHOMA

STATE OF OKLAHOMA, ex. rel. W.A. DREW EDMONDSON, in his capacity as ATTORNEY GENERAL OF THE STATE OF OKLAHOMA and OKLAHOMA SECRETARY OF THE ENVIRONMENT, J. D. Strong, in his the capacity as the TRUSTEE FOR NATURAL RESOURCES FOR THE STATE OF OKLAHOMA,	)	
Plaintiffs,	)	
	)	**Case No. 05-CV-329-GKF-SAJ**
v.	)	
	)	
TYSON FOODS, INC., TYSON POULTRY, INC., TYSON CHICKEN, INC., COBB-VANTRESS, INC., AVIAGEN, INC., CAL-MAINE FOODS, INC., CAL-MAINE FARMS, INC., CARGILL, INC., CARGILL TURKEY PRODUCTION, LLC, GEORGE'S, INC., GEORGE'S FARMS, INC., PETERSON FARMS, INC., SIMMONS FOODS, INC., and WILLOW BROOK FOODS, INC.,	)	
Defendants.	)	

EXPERT REPORT OF

Timothy J. Sullivan, Ph.D.
President

E&S
Environmental
Chemistry, Inc.

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It is well known that the land uses that are common in the IRW are often associated with contributions of nutrients such as P and fecal indicator bacteria to streams. It is also well known that it is very difficult to quantify the relative contributions from the various source types. EPA (2002, page 14) stated the following:

> ***Detecting and ranking sources of pollutants*** *(to streams)* ***can require monitoring pollutant movement from numerous potential sources, such as failing septic systems, agricultural fields, urban runoff, municipal sewage treatment plants, and local waterfowl populations. Often, states are not able to determine the particular source responsible for impairment.***

In the IRW, Plaintiffs have not conducted the monitoring identified by EPA (2002) as required to determine the particular source(s) responsible for impairment of the streams in the watershed with respect to existing water quality standards for total P and fecal indicator bacteria. However, Plaintiffs' water quality data do allow a general assessment of source areas of P and fecal indicator bacteria; concentrations of these constituents tend to be highest downstream from urban areas and WWTP facilities (see discussion in Section III.5).

Land use in the IRW includes a large amount of agricultural land, most of which is used for pasture and hay production. Urban lands also occur, and are mainly found in the upper reaches of the watershed, in the headwater areas of the Illinois River and several of its tributary streams. It is well known that watersheds having agricultural and urban land use are more likely to receive inputs of nutrients to streams and to have their drainage waters classified as eutrophic than are watersheds having forested land use (Alexander and Smith 2006).

4. *There are large numbers of people and their animals in the IRW, and Plaintiffs' consultants did not fully consider their importance as potential sources of nutrients and fecal indicator bacteria to stream waters within the watershed. Plaintiffs' consultants also did not fully consider the importance of the rapid increase in the human population that has occurred within the IRW in recent decades.*

Current and Recent Population Estimates

Plaintiffs' consultants largely ignored the substantial current human and cattle populations in the IRW and the extent to which the human population has been increasing in recent years, with concomitant increased potential for NPS contributions to streams.

Based on the U.S. Census, there were about 237,000 people in the IRW in the year 2000, of which approximately 160,500 lived in sewered communities, and 76,500 lived in rural areas, presumably on septic systems (Table 4-1). Such a large number of people would be expected to contribute NPS pollutants to stream waters within the watershed regardless of whether or not poultry litter had been land-applied. Pollutant sources would be expected to include bacteria and nutrients contributed via human waste (for example, from waste water treatment plant effluent, septic system drainage, leaking sewer pipes, accidental bypasses of raw sewage, land application of biosolids) and via pet waste. In addition, P can be contributed from soaps and other household products, lawn and garden fertilizer, and urban runoff from impervious surfaces (roofs, roads, sidewalks, parking lots, etc); such runoff would include nutrients and bacteria from fertilizers and animals such as birds, deer, and other wildlife, as well as pets. Roads (especially dirt roads), culverts, and stream banks from which soil-holding trees and other plants have been removed are well-known sources of erosion. Erosion includes the movement (via water, gravity, and/or wind) of soil from the land surface to a stream. It preferentially involves movement of the smaller soil particles (especially clay size particles), and erosion can carry a substantial amount of P adsorbed to soil particles.

I estimate, using American Veterinary Medicine Association estimates for 2001 of 1.7 dogs and 2.2 cats per household in the United States (http://www.avma.org/reference/marketstats/ownership.asp) together with the U.S. Census estimate of 2.67 people per household (http://www.petpopulation.org/faq.html) and the human population estimates given in Table 4-2, that there are over 189,000 dogs and 244,000 cats in the IRW. This assumes that these national estimates are applicable to the IRW, so there is some uncertainty in these estimates. Regardless, it is clear that there are large numbers of dogs and cats in the watershed. It is also obvious that these pets are especially numerous in the upper reaches of the watershed where most of the people live. Pet waste constitutes an important potential source of fecal indicator bacteria and P to urban runoff.

It is noteworthy that developed areas, which include most of the people and therefore many of the pets that reside within the watershed, also contain relatively high percentages of impervious land, from which contaminants from pets, fertilizer application, erosion, and other sources can move rapidly and efficiently to streams. This pollutant transport pathway is accentuated by storm drains, gutters, and roadside ditches that are constructed in urban areas in order to facilitate efficient movement of water into streams during rainstorms. Such water routing infrastructure is an important tool for reducing flooding in urban areas. However, it also provides an efficient conduit for transporting contaminants from the urban landscape to streams. Waste from urban wildlife, including deer, rodents, and birds, as well as cats and dogs, can further add to the flux of contaminants to streams in the urban areas.

Defendants' expert, Dr. Clay (2008), estimated that there are approximately 199,000 cattle, 166,000 swine, 8,000 horses, and 2,000 sheep present in the watershed. Cattle, in particular, have access to streams and streamside (riparian) areas throughout the watershed. Cattle tend to spend a disproportionate amount of their time in and adjacent to streams because such areas provide a source of water, often a source of shade, and an opportunity for cooling during summer months (Clay 2008).

Plaintiffs' consultants contend that cattle do not contribute P to the IRW because they merely recycle the P that is already present in the forage that they consume. This contention reflects a complete misunderstanding of NPS pollutant transport processes. As discussed in Section III.17 of this report, the mere presence of P within the watershed reveals nothing about the propensity of that P to move into a stream; one must also consider the transport opportunities and pathways. Similarly, one cannot ignore the importance of cattle-mediated transport of P from the location of forage ingestion in a pasture directly to the stream or to the riparian area adjacent to the stream. This is critically important because P is typically not readily transported from pasture to stream. Rainfall on much of the surface of a pasture tends to infiltrate into the soil where the P can become adsorbed, rather than running off the surface as overland flow (see discussion in Section III.7 of this report). In contrast, cattle that have free access to streams can directly deposit their feces (with its P and bacteria content) into a stream or to the adjacent riparian land that may be hydrologically active, from which transport to the stream can readily occur during a rainstorm. Thus, the actions of cattle, consuming forage throughout the pasture and then preferentially depositing their feces in or near the stream, constitute an important source contributing P and fecal indicator bacteria to streams in the IRW that was largely ignored by Plaintiffs' consultants.

It is largely because cattle can represent a major NPS pollutant transport mechanism in pasture settings that agricultural best management practices (BMPs) commonly entail construction of fences (with associated off-stream watering systems) to keep cattle out of riparian zones and streams. Intended benefits of riparian fencing include reduced contamination of stream water with livestock feces and its associated nutrient and bacteria content, reduced trampling of riparian vegetation, and reduced stream bank and riparian erosion. Riparian fencing resource protection actions occur nationwide, in many cases funded by the federal government.

It is well-recognized that cattle pose an important source of NPS pollution to streams. In fact, Total Maximum Daily Load (TMDL) analyses in watersheds throughout much of Oklahoma typically conclude that cattle constitute the principal source of fecal indicator bacteria to streams (See discussion of this issue in Section III.6 of this report). Nevertheless, Plaintiffs' consultants largely ignored or dismissed the importance of cattle in the IRW, despite the large numbers of cattle present and the wide prevalence of their access to streams within the watershed.

Plaintiffs' consultants also failed to fully address the fact that feces from an estimated 170,000 swine that live in the IRW are commonly land applied. Waste water treatment biosolids have also been land applied (Jarman 2008). Plaintiffs' consultants did not appropriately address these potential sources of contaminants to stream water, but instead focus on poultry litter, nearly to the exclusion of other known and suspected sources of P and fecal indicator bacteria.

<u>Change in Populations Over Time</u>

The human population in the IRW has been increasing dramatically for the past several decades. Between 1990 and 2007, it increased by about 77% (Table 4-2). In fact, northwest Arkansas has been one of the fastest growing metropolitan areas in the United States in recent years. The total human population in the watershed has increased from about 168,000 people in 1990 to about 297,000 people in 2007 (Table 4-2).The estimated total human population in the IRW increased by over 40% just within the decade of the 1990s. Much of this increase has occurred in the headwater areas of the IRW in the northeastern portions of the watershed. Changes over just a seven year period of time are mapped in Figure 4-1. Human population increases have been especially pronounced in the upper (easternmost) part of the watershed.

Along with the large increase in human population has been a large amount of construction: of housing, shopping centers, and other human infrastructure. Construction activities and urban development are especially widespread throughout the headwater portion of the watershed. For example, Grip (2008) mapped, from examination of aerial photographs and existing maps, new land development in a study area between Rogers and Fayetteville, within the IRW. The study area comprised 152 square miles. Mr. Grip obtained aerial photographs that covered the study area, corresponding to four time periods: 1976-1982, 1994-1995, 2001, and 2006. Developed areas that involved residential and commercial development were identified and mapped, excluding any development that was focused on golf courses, parkland, forestry, crops or pasture. During the initial time period examined (1976-1982), 12.6% of the study area was classified as developed. By 1994-1995, this increased to 22.4%; by 2001, it increased to 29.4%. The cumulative development by 2006 had increased to 39.3%, more than three times the amount of developed land in the earliest period examined (approximately 24 to 30 years previously).

With construction and urban development, there is a substantial increase in the amount of impervious land surface (pavement, roofs, parking lots, compacted soils, etc). Runoff during rainstorms from these impervious areas is largely not directed down through soils (which could remove bacteria from the drainage water), but rather flows overland and through storm drains, providing direct conduits for bacterial and nutrient transport from the ground surface to stream water. Thus, eroded sediment and also bacteria and P deposited on the ground surface by pets, hobby farm livestock, or wild mammals and birds can be efficiently transported from such areas to streams. For this reason, urban areas and developed areas commonly constitute important sources of NPS pollutants to streams. Plaintiffs' consultants have ignored the rapid increase in the human population within the watershed, along with the concomitant large increase in such potential sources of stream pollution.

5. *Effluent and drainage water from urban areas in general, and municipal waste water treatment plants in particular, are major sources of P to surface waters in the IRW.*

Urbanization is well-known as a major source of NPS pollution in the United States (Dillon and Kirchner 1975, Novotny 1995). Nevertheless, it was not fully considered by Plaintiffs' consultants in this case. Other than providing a limited and incomplete evaluation of waste water treatment effluent sources to streams and deleting watersheds having urban land use from some analyses, aspects of urban contribution of NPS pollution were generally not investigated by Plaintiffs' consultants.

My analyses show that spatial patterns in measured total P concentrations in stream waters of the IRW indicate an association with urban land use, and especially with the location of WWTP effluent discharge. Analyses conducted and reported by Defendants' expert Dr. Connolly (2008) further support this conclusion. As described below, highest values of stream total P concentration tend to be located downstream of urban land use and especially downstream of WWTP effluent sources to the streams. Plaintiffs' own data show that the sites that exhibit the highest concentration of total P, expressed as the geomean of five or more samples at a given location, are immediately downstream of the locations of WWTPs, sewage lagoons and/or urban areas.

Plaintiffs' consultants ignored or failed to recognize that stream water P concentrations in the IRW tend to be highest immediately downstream of urban pollution sources. Their analyses were directed towards portions of the watershed assumed to receive land application of poultry litter, and they failed to fully consider the presence of other potential sources of the same constituents that they claimed were contributed to streams from poultry litter application.

As an example, Plaintiffs' consultants collected paired stream samples above and below three waste water treatment plant effluent discharge locations. The resulting total P data are depicted in Figure 5-1, showing that the concentrations of total P in the streams were generally below the 0.037 mg/L standard at the locations above the WWTPs, but substantially higher immediately downstream from the WWTPs. Plaintiffs' consultants did not report such observations in their various reports for this case.

Similarly, an analysis of data collected by Plaintiffs' consultants at variable distances downstream from several WWTP locations (shown in Figure 5-2) illustrate that concentrations of total P in stream water tend to be highest immediately downstream of the location of the WWTP effluent discharge point, and subsequently decrease further downstream **(**Figure 5-3). Similar results were found by Haggard et al. (2001) in an investigation of the effects of the Columbia Hollow WWTP on Spavinaw Creek, Arkansas; they found a marked increase (about 8 to 25 times higher) in soluble reactive P in the stream immediately below the point of WWTP discharge compared with above the discharge, with a gradual decline in the P concentration in the downstream direction below the WWTP. The concentration of P in stream water decreases gradually in a downstream direction from the WWTPs in part because P settles to the stream sediment. The P that accumulates in the sediment can later be remobilized by high stream flows or in response to changing equilibrium conditions between the stream water and the sediment. Haggard et al. (2001) further concluded that the nutrient retention capacity of the stream was greatly reduced as a consequence of the point source. They concluded that:

> ***PS [**point source**] inputs diminish the ability of the stream to withstand other anthropogenic nutrient inputs***

All of these spatial patterns observed in the Plaintiffs' database illustrate the strong association between WWTP effluent (and also urban land use in general) and the occurrence of relatively high concentrations of total P in streams in the IRW. These patterns suggest that the largest sources of P to streams in the IRW are likely associated with urban development. This finding is not new or surprising. As discussed more fully below, urban development is commonly associated with both point and nonpoint source pollution of streams. There is a great deal of urban development in the IRW, and much of that development is recent. Nevertheless, Plaintiffs' consultants generally chose to focus on a presumed linkage with land application of poultry litter, almost to the exclusion of other sources, including the urban sources that their own data implicate as critically important in this watershed.

The finding that stream P concentrations in the IRW are strongly associated with waste water treatment effluent discharge is not new. The Arkansas Department of Pollution Control and Ecology, Water Division (ADPCE 1995) reported results of a study on water quality and biological response in Sager Creek in response to the effects of waste water discharge into the creek from the City of Siloam Springs. Stream samples were collected between July 1993 and June 1994 above and below the point of Siloam Springs waste water treatment plant effluent discharge into Sager Creek. The work was done in response to objections by the State of Oklahoma to proposed discharge permit modifications. Water quality samples were collected and analyzed for total P (and other parameters) approximately once every two months during the one-year study. Two sample sites bracketed the waste water treatment plant: site SAG07 was located 500 ft above the outfall, and site SAG09 was located 500 ft below the outfall. The median (of six samples) total P concentration was 0.06 mg/L at site SAG07, which increased dramatically to 1.38 mg/L at site SAG09, presumably due to the influence of the effluent contribution to the stream. In addition, samples were collected during a low-flow period on June 28, 1994 and during a high-flow event on November 16, 1993. During both flow regimes, stream concentrations of total P were relatively low upstream from the treatment plant, but dramatically higher (especially during low flow conditions) at the site (SAG09) immediately downstream from the waste water discharge (Figure 5-4). During high flow conditions, the concentration of total P increased by more than a factor of 1.5 from immediately above to immediately below the WWTP; during low flow, the difference was more than a factor of 20.

Haggard et al. (2004) reported soluble reactive P (SRP) concentrations immediately downstream of WWTPs on Spring Creek and Sager Creek in the IRW in July 2002. Concentrations of SRP in stream water below the respective WWTP exceeded 1.5 mg/L in Sager Creek and 6 mg/L in Spring Creek; these concentrations were more than an order of magnitude higher than at the sampling locations above the WWTPs and more than an order of magnitude higher than the water quality standard for Scenic Rivers in Oklahoma. Haggard et al. (2004) concluded, based on their study and also numerous other literature citations that:

> ***Phosphorus concentrations in streams generally show a sequential decrease with increasing distance from municipal WWTP effluent discharge.***

Thus, the importance of WWTPs to stream P concentrations in the IRW and elsewhere is not new information. This has been well known for a long time (See studies cited by Ekka et al. (2006) and study by Haggard et al.(2003). Ekka et al. (2006) published an in-depth study of waste water P contributions to streams and stream chemistry in 2002 and 2003 from the cities of Fayetteville, Rogers, Springdale, and Siloam Springs in NW Arkansas. Effluent discharge significantly altered water chemistry, including P concentration, in Mud Creek, Osage Creek, Sager and Flint Creeks, and Spring Creek. These are all tributaries to the Illinois River within the IRW. Mean discharge (stream flow) downstream from the effluent inputs increased from 2 to 57 times compared with the discharge measured upstream of the WWTPs. This illustrates that these headwater streams are effluent dominated. The Fayetteville and Rogers WWTPs discharged water with average total P concentrations of 0.25 and 0.35 mg/L during the study period into Mud and Osage Creeks, respectively. The Springdale WWTP discharged an average effluent TP concentration of 4.4 mg/L into Spring Creek. Average effluent P concentration was not available from the Siloam Springs facility, but it appeared that the change in dissolved P concentration in Sager and Flint Creeks was somewhere between those of Spring Creek and Mud or Osage Creeks (Ekka, 2006). Results from this study showed that stream SRP concentrations increased several fold downstream from effluent inputs (Table 5-1). The most profound effect of WWTP effluent on stream P values was in Spring Creek, which had the highest SRP concentration measured in the study (7.0 mg/L in August 2002). This is more than 189 times higher than the 0.037 water quality standard that is applicable to the main stem rivers in this watershed. Ekka et al. (2006) concluded from his study of streams in the IRW that:

> ***point sources such as municipal waste water treatment plant (WWTP) effluent discharges still exert a prominent influence on dissolved phosphorus (P) concentrations and transport in Ozark streams, particularly in northwest Arkansas, USA (**several cited references**)***

Effluent discharges increase the concentration of P in the water column, and also increase P in the stream sediment (Ekka et al. 2006 and numerous other citations provided by Ekka et al. 2006). As a consequence, Ekka et al. (2006) concluded that:

> ***The influence of WWTP effluent discharge on benthic sediments is generally much greater than other external factors, such as agricultural land use and nonpoint source pollution in the Ozarks (Popova et al. 2006).***

The ability of stream sediments to adsorb P is often much less downstream from effluent discharge points, compared with locations upstream (Ekka, 2006). This can cause P concentrations in stream water to be higher, in response to inputs from any source, as a consequence of the P contributed to the stream sediments from the effluent discharge.

Haggard et al. (2003c) sampled 30 stream sites in the IRW from 1997 to 2001, including sampling sites on the main stem Illinois River, Clear/Mud Creeks, Osage Creek, and Spring Creek. They concluded that:

> ***The spatial distribution of these sites clearly identified elevated P concentrations at the Illinois River at Highway 59*** *[near the Arkansas/ Oklahoma border]* ***were likely from a single WWTP*** *[Springdale]* ***over 46 kilometers upstream… Over 35% of the P transported during surface runoff conditions was likely from resuspension of P retained by stream sediments. Thus, these sediments may represent a considerable transient storage pool of P after management strategies are utilized to reduce elevated P concentrations at the Illinois River.***

Dr. Olsen claimed, based on his principal components analysis (PCA), that samples for which his first principal component (PC1) was equal to or above his designated cutoff value of 1.3 exhibited what he identified as a unique poultry waste signature. Yet his own data show that base flow stream sites having PC1 above 1.3 are largely located immediately downstream of urban areas and WWTPs (Glenn Johnson 2008, his Figure 3-16). Based on this observed spatial pattern, Dr. Glenn Johnson (2008, page 56) concluded:

> ***Whatever is driving PC1 … it is in large part coming from areas of high human population, in absence of poultry***

Defendants' expert, Dr. Jarman (2008) documented contributions of P and fecal indicator bacteria to the IRW as permitted discharges from WWTPs, accidental bypasses/overflow releases, and land application of biosolids. He also provided data illustrating a poor history of responsiveness by Oklahoma regulatory agencies in dealing with violations by point sources which caused contributions of these constituents to surface waters in the IRW. The importance of point source contributions of nutrients to streams in the IRW have been well recognized at least since the 1980s (Jarman, December 2008). Plaintiffs' consultants have under-emphasized the continued importance of point source contribution in this watershed, by failing to recognize the clear association of P concentrations in streams within the watershed with locations of WWTPs, selectively deleting (without properly clarifying the effects of this action on key conclusions) from some of their analyses sites that were downstream from WWTPs (Dr. Engel, 2008), and choosing a human per capita P production rate at the lower end of available estimates (Ms. Smith and Dr. Engel, as per Figure 8 in Jarman, 2008).

Phosphorus concentrations in WWTP effluent were higher in the past than they are currently because of more recent P limitations placed on effluent and because of the elimination of phosphate laundry detergent. The manufacture of phosphate detergent for household laundry was ended voluntarily by the industry in about 1994 after many states, including Arkansas, had established state-wide phosphate detergent bans (Litke, 1999). After WW II, powdered clothes washing detergents were about 15% P by weight. In 1970, the industry limited the P content to 8.7% by weight in response to national concerns about eutrophication. In 1971, five cities in Illinois limited P-containing laundry detergents. The number of states having phosphate detergent bans increased steadily after 1971, up to 26 states by 1995. During the 1940s, the total P concentrations in raw household waste water effluent averaged about 3 mg/L, increasing to about 11 mg/L at the height of phosphate detergent use about 1970, and have since declined to about 5 mg/L (Litke, 1999).

Although substantial progress has been made in reducing point source contributions of P to streams in the IRW, it is likely that many of the improvements are only recently having an influence on water quality. In the mid-1990s, Arkansas and Oklahoma state agencies and cities agreed to consider methods to reduce P inputs by 40%, and P limitations were placed on WWTPs in the IRW (Jarman, December, 2008). However, for most treatment plants, these changes were not fully implemented until about 2003, and some still do not have discharge limitations (Jarman, December 2008). Therefore, the influence of these point source reductions may not be evident in much of the available water quality data for this watershed, especially the data collected prior to about 2003. Defendants' expert, Dr. Jarman reported approximately a 40% decline in P contribution in WWTP effluent in the IRW between the period 1997 -2003 and the period 2004-2007. This decrease corresponded with approximately a 40% decline in the concentration of P in base flow stream water in the Illinois River at Tahlequah, near the upper end of Lake Tenkiller (Connolly 2008).

Despite these substantial improvements in P contribution from WWTP point sources to streams in the IRW, even for the WWTPs that do now have more stringent P limitations, these limitations of 1 or 2 mg/L of TP in the effluent are still 27 to 54 times higher than the 0.037 mg/L standard for the Scenic River sections of the stream system in the IRW.

Nelson et al. (2003) estimated P loads and concentrations in the Illinois River at the Highway 59 bridge crossing in Arkansas, near the Oklahoma state line, and compared them with loads and concentrations estimated for five other streams. They found that their estimates of base flow concentrations of total P for five of the six watersheds (all except Moores Creek) were similar (near 0.25 mg/L), and stated:

> ***This is a possible confirmation that the base- flow concentrations are effected by wastewater treatment plant discharges, as Moores Creek is the only watershed without a permitted WWTP discharge.***

The WWTPs in Springdale, Fayetteville, Siloam Springs and Rogers have all agreed to reduce effluent total P concentrations to less than 1 mg/L (Ekka et al. 2006). Nevertheless, this voluntary reduction, if fully implemented, will still allow effluent discharged from these facilities into IRW streams to contain total P that is 27 times higher than the 0.037 mg/L standard.

WWTPs are not the only potential municipal sewage point sources of nutrients and fecal indicator bacteria to streams within the IRW. Jarman (2008) documented problems associated with the Watts total retention (lagoon) waste water treatment facility, which is situated within a quarter of a mile of the main stem Illinois River in Oklahoma, adjacent to the Arkansas state line. Although there is no effluent discharge from this sewage treatment facility, there is still the risk of pollution contributions to the river due to land application of treated sewage. The land application area associated with this facility is located within about 100 feet of the river. The U.S. Fish and Wildlife Service (USFWS) expressed concerns over a proposal for the Watts facility to begin taking waste water from the city of West Siloam Springs. The USFWS concern centered on application of treated waste water to hydric soils in the flood plain of the Illinois River. Jarman (2008) reported an accidental release of 275,000 gallons of treated waste water from the facility in 1999, which resulted in assessment of a $20,000 penalty by ODEQ. An assessment prior to this accidental release by Enercon Services, Inc, in a study commissioned by the Oklahoma Attorney General and the OSRC, concluded that:

> ***its proximity to the River and the presence of numerous pathways virtually assures that the Illinois River will be the target of and ultimate recipient of the contaminants associated with the Watts lagoon. (****cited in Jarman 2008****)***

It is important to note that, even though municipal sewage treatment facilities, such as WWTPs and the Watts lagoon, constitute an overwhelmingly important source of nutrients to stream water, they are not the only important sources of NPS water pollution associated with urban development. Runoff from urban areas also is well known to contribute substantial amounts of fecal indicator bacteria, nutrients, sediment, and other constituents to drainage water. Urban sources of these constituents can include fertilizer use on lawns and parks, pet and urban wildlife waste, erosion associated with construction activities, and broken or leaking sewer pipes.

Urban areas contain relatively high proportions of impervious land (i.e., parking lots, compacted soils on construction sites, roofs, roads, sidewalks, etc.), from which contaminants of all kinds can be rapidly flushed to streams during rain storms. Urban areas are specifically designed so as to move rain water quickly and efficiently to streams in order to prevent flooding. This is typically done via installation of extensive systems of storm drains, gutters, and roadside ditches. An unfortunate effect of such rapid routing of runoff into streams within urban areas is that there is much less opportunity for constituents such as P and fecal indicator bacteria, which tend to be removed from infiltrating water and retained on soils, to be removed from the runoff before it enters a stream. In urban areas, less water is routed through soils; more water is routed overland. As a consequence, proportionately more P and bacteria are carried from the land into the stream. This concept is not new; it is not specific to the IRW. Rather, it is a well-known facet of NPS pollution science. It was ignored by the Plaintiffs' consultants in this case.

Novotny (1995, page 23) concluded that urbanization is probably the greatest source of NPS pollution to streams. Nevertheless, it was not considered by Plaintiffs' consultants in targeting their sampling or interpreting much of their resulting data. Urbanization changes the hydrology of the watershed to favor transport of pollutants from the land surface to streams. Lawn fertilizers, pet waste, and urban wildlife waste are flushed into storm drains, bypassing the soils that might otherwise adsorb some of the contaminants present in that water. Soil loss to erosion from construction sites can reach magnitudes of over 100 tons per hectare per year. For that reason, construction occurring in only a small percentage of the watershed can contribute a major portion of the sediment carried by streams in the watershed (Novotny 1995, page 25). This sediment contributes directly to elevated suspended solids and turbidity; it also carries P. Novotny (1995, page 24) cautioned that newly developing urban lands (which are very common in the IRW) should receive special attention in NPS assessment:

> ***this stage of land is characterized by the high production of suspended solids caused by erosion of unprotected exposed soil and soil piles…Extremely high pollutant loads are produced from construction sites if no erosion control practices are implemented. Therefore, in establishing pollutant loadings relative to land uses, one must determine first whether the area is fully developed or if it is a developing area and/or significant construction activities are taking place therein.***

Novotny's caution is especially relevant to NPS pollution in the IRW. As described in Section III.3 of this report and by Grip (2008), new construction is widespread in the IRW, and northwest Arkansas has been in recent years one of the fastest growing metropolitan areas in the United States.

With an increase in the amount of impervious surfaces in response to urbanization, the urban portions of the watershed become more hydrologically active. Runoff events carrying heavy pollutant loads become more common (Novotny, 1995, page 27). Pollutants that accumulate in the streets, parking lots, and areas of compressed soil are readily transported in surface runoff. These pollutants can include dust and soil particles (which can be high in P content), animal waste, atmospherically deposited nutrients, and fertilizers. High-density urban zones are nearly completely impervious and have very limited capacity to attenuate pollution, with almost all emitted pollutants eventually reaching surface waters (Novotny and Olem 1994, page 493). Novotny (1995, page 45), based on EPA's Nationwide Urban Runoff Project (NURP), estimated that the event mean concentration of TP in urban runoff for the median urban site was 0.37 to 0.47 mg/L, with the 90th percentile urban site yielding an event mean concentration of TP equal to 0.78 to 0.99 mg/L. The TP in urban runoff would be expected to be partly from erosion and partly from other P contributions associated with such factors as fertilizer use, pet waste, leaking or faulty sewer lines, urban wildlife, and other sources.

Data from EPA's National Urban Runoff Program (U.S. EPA, 1983) found that the median urban stream site in the United States received storm runoff having total P concentration of 0.37 (10 times higher than the Illinois River standard) to 0.47 mg/L, with 10% of values more than twice as high (Novotny 1995, page 61). EPA (1983) further concluded that:

> ***Fecal coliform counts in urban runoff are typically in the tens to hundreds of thousand per 100 ml during warm weather conditions, with the median for all sites being around 21,000/100ml.***

For comparison, the median concentration of fecal coliform bacteria in streams sampled in the IRW by Plaintiffs' consultants in areas representing a variety of land uses and reported in Dr. Olsen's database was 130 cfu/100 ml.

It has been previously shown that nutrient exports from urban watersheds can be as high, or higher, than exports from agricultural lands. For example Osborne and Wiley (1988) investigated land use and stream water quality in the Salt Fork watershed in Illinois, which is primarily (90%) agricultural. Urban areas accounted for 5% of the total watershed areas, which (as in the IRW) was concentrated in the upper watershed. They found that:

> ***Despite the over-riding dominance of agricultural land use within the Salt Fork watershed, our results demonstrate that urbanization rather than agriculture has the greatest impact on stream SRP concentrations.***

The Illinois River Management Plan (OSRC, OSU, and NPS, 1999) concluded that:

> ***Urban runoff is recognized as one of the major non-point sources of pollutants within watersheds. The Illinois River Corridor is a mixture of moderately populated urban areas with a large growing suburban and rural population.***

Urban land use has also been associated with negative impacts on stream biological integrity. For example, Wang et al. (1997) found that urban impacts on stream biological integrity in Wisconsin became severe when the percent of the watershed covered by urban land use exceeded 10% to 20%. Effects have been associated with the amount of impervious surface area, amount of developed land, and population density (Klein 1979, Benke et al. 1981, Jones and Clark 1987, Lenat and Crawford 1994).

Parsons and University of Arkansas (2004) characterized water quality and aquatic biological resources of several streams in the IRW. The objective was to provide data to U.S. EPA for use in evaluating potential 303(d) listings of water quality impairment for Arkansas. They concluded that multiple stressors are affecting this system at all times. Water chemistry nutrient results at locations downstream from WWTPs were nearly always higher in nutrient concentrations than the respective upstream location. Of the 12 sites assessed in the IRW for this study, one was classified as “severely impacted” and two were classified as “impacted” on the basis of multiple chemical and biological indicators of environmental health. The severely impacted site was located on Spring Creek below the Springdale WWTP. One of the impacted sites was located on Muddy Fork below the Prairie Grove WWTP. The other impacted site was located on Osage Creek, below urban development and multiple WWTP discharge locations.

According to data compiled for this case by Defendants’ expert, Dr. Ron Jarman, WWTP effluent within the IRW usually contains about 10 to 40 cfu/100 ml, on average, of FCB. Nevertheless, effluent discharged directly into the Illinois River system sometimes contains levels that exceed the 200 cfu/100 ml Primary Body Contact Recreation standard, including values in the thousands of cfu per 100 ml. Such values of bacteria in the effluent from WWTPs contribute to the overall bacterial concentrations in the streams within the watershed.

Routine operation of WWTP facilities contributes well known point sources of P and fecal indicator bacteria. In addition to these routine contributions, there are numerous accidental releases of these constituents to the stream system. The accidental release of raw or partially treated sewage is not an unusual event in the collection system of a WWTP. This can introduce large amounts of nutrients and fecal indicator bacteria to stream waters. Jarman (2008) noted that there are many causes for these events, including line breakage, blocking or plugging of the lines, construction damage, heavy rainfall, and system breakdowns at a lift station or the WWTP. Such events represent a recurring source of nutrients and fecal bacteria in urban settings.

Dr. Jarman documented sewage bypasses (uncontrolled discharge of untreated or partially treated sewage) within the watershed over a period of seven years. Although data were not available from all townships within the watershed, and data were only available for some years in others, Dr. Jarman reported about 700 hours of sewage bypass with average concentrations of FCB in the range of 1.5×10^{15} (one and a half thousand trillion) or higher per bypass event (Table 5-2). Most of these bypasses involved raw sewage, in volumes that averaged 500 gallons (Westville) to 9,060 gallons (Lincoln). I have become aware of additional bypass data that were not included in Table 5-2, indicating two bypasses from the Stilwell facility comprised of 1 million and 800,000 gallons of raw sewage. These bypasses data were discussed by Dr. Madden in his September, 2008 deposition for this case (Madden 2008, deposition transcript, pages 61 to 71). Thus, sewage bypasses constitute an important additional source of fecal bacteria to stream water in this watershed.

Mixed land use watersheds often have mainly forests in the upper reaches, and urban and agricultural land uses in the lower reaches. Therefore, contaminants that might be contributed to the streams from humans and their activities and their livestock often increase in a downstream direction, from the headwaters to the larger streams that are found downstream. The IRW is fairly unusual in that urban development is concentrated mainly within the headwater areas of the watershed (See Figure 3-1). For that reason, stream waters in the IRW tend to have relatively high concentrations of P and fecal indicator bacteria even within the upper stream reaches. This makes it difficult to evaluate the relative importance of different sources of contaminants found in the non-urban areas in this watershed. The Comprehensive Basin Management Plan for the IRW (Haraughty 1999, page 30) correctly identified that:

> ***…much of the phosphorus comes from the headwaters of the watershed, thus remediation efforts should concentrate in this area.***

Stream water data collected by Plaintiffs' consultants for this case clearly show the dominant influence of urban areas in general, and WWTPs in particular, on stream total P concentrations and to a lesser extent stream *E. coli* concentrations. Figure 5-5 illustrates the spatial patterns in total P concentrations in the IRW during low flow conditions, based on the geomean of 5 or more samples calculated from Dr. Olsen's database. The same pattern is seen for Dr. Olsen's data when samples collected under all flow regimes are included (Figure 5-6).

The water quality standard for P in the IRW is frequently exceeded even under low flow conditions (Figure 5-5), at times when NPS pollution associated with activities on pasture lands would not be expected to contribute appreciably to stream water quality. Such exceedances of the P water quality standard during low flow are probably caused primarily by point sources of pollution, mainly waste water treatment plant discharge from municipalities, directly into streams within the watershed. All of the low flow geomean P values that were relatively high were based on samples collected downstream from a developed area and downstream from a WWTP.

Dr. Olsen's database contains fewer samples analyzed for *E. coli*, so for those maps the criterion was relaxed to include all sites for which there were at least three (rather than 5) samples on which to base the geomean calculation. Geomean *E. coli* results for base flow and for all flow conditions are shown in Figures 5-7 and 5-8, respectively. Although there are fewer sample locations that met the criterion for number of samples, the patterns are similar. Again, the highest geomean concentrations tend to be located downstream from urban areas and WWTPs.

Thus, with nearly 300,000 people living in the IRW, mostly in urban areas in the upper watershed, there are clearly substantial sources of fecal indicator bacteria and nutrients to streams that flow through these urban areas. Plaintiffs' own data show this. The scientific literature shows this. Attempts to place most of the blame on land application of poultry litter (or any other source in the non-urban portions of this watershed) simply makes no sense.

6. *Within non-urban areas in the IRW, there are many potential sources of P and fecal indicator bacteria to stream waters.*

In addition to urban sources of NPS pollutants to streams in the IRW, described above, there are also multiple potential sources of P and fecal indicator bacteria to stream waters within the non-urban portions of the watershed. Plaintiffs' consultants **assume** that poultry litter application is the only, or the dominant, source in non-urban areas. They do not adequately assess the importance of the other potential sources. These other potential sources include, in particular, cattle manure, septic systems, roads and associated ditches and culverts, and other livestock and wildlife. Plaintiffs' consultants largely ignore or dismiss these other well-known potential sources of NPS pollution.